USACERL Technical Report FM-93/03
December 1992
Roof Construction Expert System

TECHNOLOGY TRANSFER TEST BED PROGRAM

Field Test of an Expert System for Construction Site Quality Assurance: Expert System for Roof Construction (ESROC)

by
Debbie J. Lawrence
Phoebe E. Lenear

The U.S. Army Corps of Engineers (USACE) relies on a limited number of quality assurance (QA) personnel to handle an increasingly large workload involving many complex practices not used in traditional construction. To ensure the continued quality of military facilities, USACERL is developing tools to enhance the productivity of QA personnel. The Expert System for Roof Construction (ESROC) was developed as a potential tool to assist QA personnel.

ESROC is an expert system that offers the user easy access to knowledge about built-up roof construction from textbooks, field manuals, training courses, and experts. The prototype of ESROC was field tested at two USACE area offices to validate its effectiveness and usefulness. ESROC was found useful, especially as a training tool, and other areas were suggested where expert systems would be beneficial.

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The U.S. Army Corps of Engineers (USACE) relies on a limited number of quality assurance (QA) personnel to handle an increasingly large workload involving many complex practices not used in traditional construction. To ensure the continued quality of military facilities, USACERL is developing tools to enhance the productivity of QA personnel. The Expert System for Roof Construction (ESROC) was developed as a potential tool to assist QA personnel.

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TECHNOLOGY TRANSFER TEST BED PROGRAM

FINDINGS AND RECOMMENDATIONS OF TEST/DEMONSTRATION

WORK UNIT NO./TITLE OF TEST: TTTB-EM-KE9
Roof Construction Expert System

PERFORMING LABORATORY: USACERL **PRODUCT/SYSTEM:** Expert System for Roof Construction (ESROC)

PERFORMING TEST SITES: USACE Southwestern Virginia Area Office and Fort Lewis (WA) Area Office

DESCRIPTION/OBJECTIVE OF TEST/DEMONSTRATION:

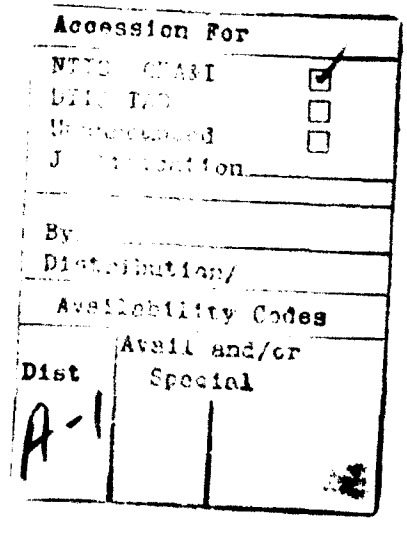
The objective of the T^3B ESROC project was to test and verify the usefulness of expert systems for quality assurance. The prototype expert system, Expert System for Roof Construction (ESROC), was used as the representative expert system. Based on the results of these tests, field-suggested modifications would be identified and incorporated to enhance the field usefulness of ESROC, thus enhancing the productivity of the QA personnel and engineers on built-up roof construction projects and ultimately improving the quality of roof construction.

RESULTS OF THE TEST/DEMONSTRATION:

Overall, test results proved that ESROC is useful in assisting in training QA personnel and engineers on built-up roof construction projects, thereby, enhancing their productivity and improving the quality of roof construction. Once appropriate field recommendations have been implemented, an efficient field-useable expert system for roof construction will result.

RECOMMENDATIONS FOR PRODUCT/SYSTEM:

It is recommended that: (1) the ESROC knowledge base be expanded to include more information on re-roofing operations, wood decks, and other roof construction processes in order to expand the applicability of ESROC; (2) expert systems be developed for other construction problem areas to allow QA personnel to have rapid and easily accessible information at the construction site; (3) ESROC be used during the design stage so value engineering can be applied to roofing system design; (4) work continue to improve the applicability and accessibility of the expert system; (5) the modified version of ESROC be field validated and used as appropriate.



FOREWORD

This research was conducted for Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Technology Transfer Test Bed (T^3B) work unit TTTB-EM-KE9, "Roof Construction Expert System." The demonstration was coordinated with the Corps of Engineers National Quality Assurance Team (CENQAT). The HQUSACE technical monitor was Richard Carr (CEMP-CE).

This work was performed by the Engineering and Materials Division (FM) of the Infrastructure Laboratory (FL), U.S. Army Construction Engineering Research Laboratories (USACERL); Pat Golden at the U.S. Army Corps of Engineers Southwestern Virginia Area Office; and Arill Berg, Victor Sandvig, and Jolene Gosselin at the Fort Lewis Area Office. Tom Gatton and Theresa Czerwinski (USACERL) were the knowledge engineers for ESROC. Phoebe Lenear, Denis Singleton, and Phil Lawrence provided review of the ESROC report information. Dr. Paul A. Howdyshell is Chief, CECER-FM. Dr. Michael J. O'Connor is Chief, CECER-FL.

COL Daniel Waldo, Jr., is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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FIELD TEST OF AN EXPERT SYSTEM FOR CONSTRUCTION SITE QUALITY ASSURANCE: EXPERT SYSTEM FOR ROOF CONSTRUCTION (ESROC)

1 INTRODUCTION

Background

Tighter budgets and scarcer resources are requiring the U.S. Army Corps of Engineers (USACE) to change many established procedures and methodologies. Defense spending cutbacks, rising construction rates, and the increasing complexity of construction technology are prompting the Corps to develop new techniques for construction that will lower construction costs while maintaining or improving the quality. At the same time, personnel are leaving the Corps for retirement or other positions. Therefore, the Corps must fulfill its mission with the help of fewer personnel, whose training and experience must necessarily be spread more thinly across larger areas of responsibility.

In the area of construction site QA, the Corps can no longer afford to employ inspectors whose expertise is limited to a single area such as electrical inspection. One inspector may be responsible for electrical, mechanical, and concrete inspections for eight different projects at one time. Technologies must be implemented which capture present knowledge, before it is lost and that quickly and thoroughly educate new QA staff members using this knowledge. These techniques may also be implemented to improve the productivity of workers currently employed.

One technology which accomplishes these goals is the expert system. An expert system is a computer-based system that contains an expert's knowledge in a certain field. It can be used by persons having limited knowledge or experience in the field and by experienced personnel.

In general, an expert system can assist the user in four different ways:

1. As a tutor. By asking questions and working interactively with the user, the system can train new employees to use the sound reasoning traditionally developed over a longer time through experience.

2. To validate a "gut feeling." The system can back up or reinforce a user's intuition.

3. To analyze factors affecting a situation. Many factors may combine to cause a problem and it is difficult to analyze all of their effects and impacts without having an expert's knowledge of the problem.

4. To gather essential information. Even if the expert system cannot completely solve the problem, it can tell the user enough about the situation so he or she can quickly and effectively consult a human expert. The system helps do the preliminary work, allowing the consultant to focus on the actual problem.

Objective

As agreed upon with the field test sites and the CENQAT team, the objective of the T^{3}B ESROC project was to test and verify the usefulness of expert systems for QA. The prototype expert system, Expert System for Roof Construction (ESROC), was used as the representative expert system. Based on the results of these tests, field suggested modifications would be identified and incorporated to enhance the field usefulness of ESROC, thus enhancing the productivity of the QA personnel and engineers on built-up roof construction projects and ultimately improving the quality of roof construction.

Approach

Built-up roof construction is considered one of the problem areas in construction that could greatly benefit from an expert system, and was therefore selected as the subject for the field test expert system.

Design of the ESROC prototype involved the following steps: first, the researchers conducted a survey of technical literature, manuals, guides, and specifications dealing with current research in roofing construction. Using information from major sources such as the Corps of Engineers Construction Inspector's Guide (EP 415-1-261 and Corps of Engineers Guide Specifications), a rough prototype shell of the expert system was created. This was subjected to an iterative process of evaluation and correction by the developers and several experts in the field. Mr. Elton Cobb, the Huntsville Division roofing course instructor, served as the primary expert for ESROC. After several iterations that included corrections and new information, ESROC was ready for field testing.

ESROC focused on problems with new construction. However, due to an Army construction freeze, the only projects available involved re-roofing and wood deck construction. This limited the choice of potential test sites.

The T^{3}B field test sites were: the USACE Fort Lewis Area Office, WA, and the Radford Army Ammunition Area Office, VA. ESROC was implemented on a Compaq SLT/286 laptop microcomputer with a virtual graphics adapter (VGA) display. QA personnel at both sites were instructed on the use of ESROC. Evaluation of the system was based on its effectiveness as a QA tool and its utility as a training mechanism.

Scope

This work was aimed at identifying methods for developing expert systems that would be beneficial and useable by field personnel with a wide range of field knowledge. However, in some expert system applications, the user's knowledge of the field may not be known.

Mode of Technology Transfer

Information in this report will be used in developing expert systems as knowledge tools for QA in military construction. As the expert systems are developed they will be transferred to the field in cooperation with the HQUSACE technical monitor through user documentation, on-site training, and tutorials. In addition, they may be appropriate for transfer to the private sector through mechanisms such as Cooperative Research and Development Agreements (CRDA).

2 THE EXPERT SYSTEM

An expert system is a computer program that contains current literature and expert knowledge of a particular discipline. The system prompts the user with a series of questions relating to this field. Upon completion of this querying session, the expert system gives a conclusion/solution. If the user is not satisfied with the system's conclusion, if he needs an explanation of the conclusions made, if he doesn't understand a mode of questioning, etc., he may inquire further by using the commands below.

The expert system uses the Critic expert system shell program. Critic is the control program that accesses the expert knowledge base, and based on the information received by the user, extracts data from this knowledge base, interprets it, and forms a solution.

Several expert systems have been created using this program: Expert System for Asphalt Paving (ESAP), Expert System for Miter Gates (MITER), Expert System for Railway Maintenance (ESRAM), and Expert System for Roof Construction (ESROC). Critic has several built-in commands which increase the amount of information the user can gain from a session of query. The following commands are available.

1. WHATIS: For each question in the expert system, this command provides an explanation of the question, including definitions of potentially confusing terms within the question. This command displays pictures or graphics where they will clarify an explanation or description.

2. CURRENT: This command allows the user to review the information already entered into the computer through his or her answers to the expert system's questions. In other words, CURRENT shows how the user has answered the system's previous questions.

3. VALUES: This command will show all the possible answers to a particular question.

4. REVISE: REVISE allows the user to change an answer already given to a particular question. This command allows the user to test the impact of different answers on the expert system's conclusions.

5. WHY: This command explains why the system has asked a particular question or why the system has reached a certain conclusion.

6. WHYNOT: WHYNOT prompts the system to explain why a particular conclusion cannot be reached, based on the user's answers to the system's questions.

7. ASSIGN: This command allows the experienced user to take control and randomly answer questions that the expert system will ask sometime during the session. With ASSIGN, the user can provide input without waiting for the system to proceed through its entire sequence of questions. When the user exits ASSIGN, the system automatically asks him or her any questions still requiring answers necessary for formulating a conclusion. (Note: ASSIGN was not functional at the time of this field test.)

8. DECIDE: If not enough information has been provided by the user under ASSIGN, DECIDE is used to exit ASSIGN and return the expert system to the mode of asking questions so it can gather any information it still may need to reach a conclusion or obtain results.

9. RESULTS: This command displays the conclusions or recommendations that have been reached after a querying session. All command options are available at this point.

9. RESULTS: This command displays the conclusions or recommendations that have been reached after a querying session. All command options are available at this point.

10. EXPLAIN: Under RESULTS, the system presents its conclusions as one-line descriptions of the solution to the problems. EXPLAIN is available for users who need a conclusion clarified with a longer explanation or a more detailed description of the proper procedure to follow. This command also displays pictures/graphics where necessary to help clarify the explanation. For instance in ESROC, pictures are presented which show the positioning of different parts of a roof along with verbal descriptions of the parts.

11. PRINTER: This command prints the user's answers to the system's questions as well as the results of the session. The command makes the system's conclusions available as a hard copy for repeated reference, sharing with others, and photocopying without requiring further access to the computer.

12. RESET: RESET prompts the program to return to the beginning of a line of questions without retaining any prior user input.

13. QUIT: This command ends the consultation session and returns the user to the menu of topics.

14. GRAPHIX: The GRAPHIX command allows the user to graphically see the expert system's logic displayed as a tree diagram. The user can still consult the expert system while in the graphix mode. This command is intended for more advanced users, allowing them to rapidly assess factors affecting the system's conclusions while permitting use of the other functions listed above.

3 DEMONSTRATION AND RESULTS

Testing took place at the Corps of Engineers Fort Lewis Area Office and Radford Army Ammunition Area Office. The tests proceeded as follows:

Testing at the Fort Lewis Area Office

Three employees with different levels of roofing inspection knowledge were chosen to use and evaluate ESROC. In this way the field test findings would include feedback from both novice and moderately knowledgeable users. The test participants used ESROC for re-roofing work on a construction site at Yakima Firing Center, Yakima, WA. Prior to the test, USACERL personnel trained two of the participants on the system. A laptop personal computer (PC) was used to run ESROC on the roof during inspections and off site in the Corps field office.

Testing at the Radford Army Ammunition Area Office

USACERL personnel trained a Radford inspector on ESROC. The system was used as a preliminary check to the office's three phase inspection system at the time of the roofing construction and as an aid to a re-roofing project. As at the Fort Lewis site, ESROC was implemented on a laptop PC for use on the roof as well as in the office.

Analysis of Test Results

The field tests performed did not utilize all of the ESROC's capabilities. The majority of Fort Lewis' and Radford's tests dealt with wood decks and re-roofing. ESROC contained little information on wood decks due to the infrequency of their use in new construction, lack of wood deck expertise, and insufficient information in the Corps' wood deck guide specifications. The original emphasis of the ESROC project was to concentrate on problems with new construction, and was therefore not complete in its coverage of re-roofing operations. It was not until ESROC was tested at these installations that re-roofing problems were fully considered. Assistance for the removal of existing roofs was at this point identified as an area for future expansion of ESROC.

The comments of field test participants are reproduced in Appendix A. Among the areas addressed for suggested improvements were the following:

1. The system was bulky, and often asked too many "unnecessary" questions. ESROC asks questions until all possible conclusions are either substantiated or found false. Because the questions are asked in a predefined order, an answer which proves a potential conclusion false may not be considered until many other questions have been asked.

2. There were a few mistakes with spelling and descriptions of some terms.

3. The capabilities provided by the WHY command was not understood by the users. A QA representative who has been briefly trained on the use of the system will probably not employ all of ESROC's capabilities because he is unfamiliar with the system.

A more advanced user, however, may frequently query WHY because he knows it will allow him to see the logical path of a rule during a consultation and to fully understand the ramifications of the different possible answers to a question.

To illustrate how the WHY command operates, the user may have a problem with some roofing felts and resorts to the system for assistance. After a few background questions concerning the roofing problem, ESROC will ask, "Do the roofing felts extend to the top of the cant? (yes or no)" Instead of answering yes or no the user asks, "Why?" ESROC answers with, "...Because if the roofing felts do not extend to the top of the cant this would suggest the roofing plies are installed wrong at the cants."

4. ESROC contained insufficien, information on areas such as, torch-on roofing membranes and flashing; sealants for sheet metal work; details on roof penetrations, roof dividers, and expansion joints; specific safety measures associated with roofing; repetitive deficiencies; and re-roofing operations.

5. The laptop PCs used in the tests were considered cumbersome on the roof and could cause membrane problems if dropped on the roof during construction.

Among the advantages of the system cited by test participants were the following:

1. ESROC is a useful QA tool and teaching aid for users who have little or moderate experience in the area of roof construction.

2. ESROC allows users to thoroughly learn important information within a short amount of time.

3. ESROC reduces a field person's reliance on his or her field knowledge to solve QA problems.

4. The system enables less experienced personnel to investigate all the obvious potential causes of a problem and express them concisely and accurately. In cases where it is necessary to consult a human expert, the information obtained from an ESROC query session will allow the consultant to focus on the aspects of the problem that actually require his or her expertise.

5. ESROC enables experienced field personnel to check their "gut feelings" about a problem's cause. ESROC can help validate their approach to solving the problem during the design or inspection stages.

At Radford, ESROC was used to diagnose the solution to a problem with the membrane and to verify that the bitumen was incorrectly specified. Without ESROC, the roof would have prematurely failed within one year.

Completed and Planned Modifications

Due to field test suggestions, several modifications to ESROC were made. Appendix B lists corrections made following field testing and other planned revisions.

An editor is currently being developed which would enable end users to make many of these corrections on their own, as well as tailor the system to fit the user's own local requirements. But, because of the lack of control and verification of the veracity of changes to the knowledge base of the expert system, it is unlikely the editor will be provided to end users.

The ASSIGN command, which was not available for use at test time, has been activated. By allowing the user to directly provide answers for questions, this command alleviates the redundancy of a query session and reduces the length of time required to reach a conclusion, thus increasing ESROC's efficiency in diagnosing problems with the roof construction. After the user is finished with ASSIGN, ESROC asks any remaining questions for which answers are needed to reach a conclusion. Therefore, any questions which are not relevant to the inspection being performed will not be asked, and the session will be shorter.

4 CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Fort Lewis Area Office and the Radford Army Ammunition Area Office field tested ESROC to verify its usefulness for QA in roof construction. Advantages as well as disadvantages in using the expert system were noted by the test sites (see Appendix A).

Overall, test results have proven that ESROC is indeed useful in assisting in training QA personnel and engineers on built-up roof construction projects, thereby, enhancing their productivity and improving the quality of roof construction. Once appropriate field recommendations have been implemented, an efficient field-useable expert system for roof construction will result.

Recommendations

It is recommended that the ESROC knowledge base be expanded to include more information on re-roofing operations and wood decks in order to expand the applicability of ESROC. Other roof construction processes should also be addressed.

It is recommended that expert systems be developed for other construction problem areas to allow QA personnel to have rapid and easily accessible information at the construction site.

It is recommended that ESROC be used during the design stage so value engineering can be applied to roofing system design.

It is recommended that work continue to improve the applicability and accessibility of the expert system, i.e., high-quality visuals of the process that is being questioned, graphic pictures of defects, etc. This would greatly increase the training aspect of expert systems.

It is recommended that the modified version of ESROC be field validated and used as appropriate.

APPENDIX A: ESROC Field Test Participant Comments

1. Fort Lewis commented that there were redundant answer selections below some of the questions and suggested that these selections be simplified.

   For example, the question:

   On what type of material is the membrane being placed?
   1) = the membrane is going directly on the deck
   2) = the membrane is going on a base sheet...

   Was suggested to read:

   On what type of material is the membrane being placed?
   1) = directly on the deck
   2) = a base sheet

   If the question in the above example were re-stated as suggested and a user decides to ask "why" this question is asked, the "why" explanation would read:

   "(Because if) directly on the deck this would suggest the steel deck joints must be sealed as specified."

   Instead of

   "(Because if) the membrane is going directly on the deck this would suggest the steel deck joints must be sealed as specified."

   From the example it can be seen that the questions are stated in this manner to maintain correct grammar in the "why" explanation. Therefore, the redundancy in the questions are necessary and cannot be corrected.

2. Fort Lewis noted that words could not be read on some of the pictures. It was found that they installed ESROC on a computer different from that supplied by USACERL. Each site was given a VGA graphics version of ESROC to be used with the PC (the PC was equipped with a VGA graphics board to support the VGA version of ESROC). Because Fort Lewis installed ESROC on a computer not supporting the VGA version, their monitors would not display this version of the pictures correctly.

   Different versions of the pictures for different graphics boards are available upon request.

ANNEX 1: User Feedback From Radford Army Ammunition Area Office

DEMONSTRATION REPORT
EXPERT SYSTEM FOR
BUILT-UP ROOFING

VI. OBJECTIVES

1. To develop an expert system (Esroc) which enhances the productivity of the QA personnel and engineers on roof construction projects and ultimately improve the quality of roof construction through the use of Esroc.

2. To produce a field usable Esroc for roof construction QA personnel and engineers.

3. To test and verify the usefulness of Esroc for quality assurance.

VII. APPROACH

1. CERL developed and produced a field usable Esroc for roof construction.

2. CENAO-XR tested and verified the usefulness of Esroc during the roof replacement contract at the U.S. Army Reserve Center in Dublin, VA.

VIIA. SCOPE

****

IX. DESCRIPTION OF DEMONSTRATION

1. CERL personnel demonstrated and instructed CENAO-XR personnel in the use of Esroc.

2. CENAO-XR personnel used Esroc prior to each phase of the three phase inspection system during construction of the roof.

3. CENAO-XR personnel used the information, explanation of results and conclusions obtained from Esroc and compared the data to the information contained in the contract documents and industry standards used for the construction of the roof.

X. ANALYSIS

1. Esroc is basically a reproduction of the Corps Guide Specifications.

2. Esroc did not contain sufficient information on:

   i. Torch-on roofing membrane and flashing.
   ii. Sealants for sheet metal work.
   iii. Various details of construction encountered (i.e., roof penetrations, roof dividers, expansion joints).
   iv. Specific safety measures associated with roofing.
   v. Repetitive deficiencies.

vi. Reroofing operations (demolition, disposal of asbestos containing roofing materials).

vii. Expert consequences of performing unacceptable work or using improper materials.

3. Esroc program was long and cumbersome. Specific results to questions were not displayed until a number of questions were answered. Explanations for all results are not displayed in one operation.

XI. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Esroc does not significantly enhance the productivity of QA personnel and engineers for the reasons stated in the analysis above.

2. It is easier, faster and more prudent to reference the contract documents instead of running through an Esroc section.

3. Esroc would be a good learning tool to train QA personnel and engineers unfamiliar with built-up roofing operations and would help to resolve problems if the recommendations are implemented.

4. Esroc would be good aide to use for architect-engineer design reviews.

5. Use of Esroc and the current Corps Guide Specifications helped reveal a problem (use of organic felt roofing membrane) and provided additional verification that the use of coal tar pitch on roof slopes exceeding 1/4-inch per foot was not acceptable.

Recommendations

1. Address items #2 and #3 in the analysis above.

2. Use Esroc as a training tool.

3. Use Esroc during architect-engineer design reviews.

4. Develop additional Esroc programs for mechanical and electrical work to be used as a training tool.

5. Provide a separate section listing repetitive deficiencies.

6. Incorporate case histories of each roofing contract used to develop and test Esroc.

7. Expand expert information and provide specific details on the consequences of proceeding with deficient work.

ANNEX 2: User Feedback From Fort Lewis

CONTRIBUTION TO TECHNOLOGY TRANSFER TEST BED REPORT

VII. APPROACH: The approach used to evaluate the ESROC program was to provide a laptop computer to a small but diverse group of area office employees and allow them to individually experiment with its use on a construction site and in a field office environment. These individuals were then asked for their input concerning the value of the program and suggestions for other applications of this technology.

VIII. SCOPE: There were no limitations on the demonstration of the expert system program except for the fact that no roofing on metal or concrete decks was occurring during the demonstration period. The program has more information on roofing over these type of decks than the wood decks at the Yakima Firing Center.

IX. DESCRIPTION OF THE TEST: The test of the ESROC Expert System for built-up roofing inspection/quality assurance consisted of the selection of three Corps of Engineers area office employees, with varying degrees of roofing inspection knowledge, to evaluate the program individually. These three were Victor Sandvig, Jolene Gosselin, and Arill Berg. Mr. Sandvig, is an experienced Construction Representative working at an outlying field office without any direct supervision and without direct access to roofing manuals or roofing experts. Mr. Sandvig had very little experience with computers in the field office but had a good working knowledge of built-up roofing. Ms. Gosselin is a recent civil engineering graduate on a rotational training program and had no experience with roofing terminology or inspection. Mr. Berg is a project engineer with 12 years of experience in civil engineering, 7 of those in construction. He attended a built-up roofing course sponsored by the Roofing Industry Educational Institute and worked as a construction representative for several years.

Each of the individuals above spent time in the field at the Yakima Firing Center in Yakima, Washington with a laptop computer to evaluate the program. The roofing project ongoing at the time consisted of a number methods of repairing or reroofing 30 wood framed buildings. Some of the buildings received completely new built-up roofs directly on the wood decks while others received new built-up roofing over the old roof systems. The computer was used on the roof as well as in the Corps field office.

X. ANALYSIS OF THE RESULTS: The results of this test were mixed. The less experienced engineer, with no significant knowledge of built-up roofing systems, learned a significant amount about the subject in a short period of time. Although somewhat annoyed by spelling errors, the "why" command, and not being able to jump around from one subject to another in the program, she was positive about the graphics and the amount of information in the program. The construction representative was also positive about the program and learned (or remembered) more about built-up roofing than he had expected. The project engineer went through the program in more detail and found numerous aspects of the program that would tend to discourage the user. He felt that the program should be structured more as a tutorial and resource, than as an expert asking questions and then drawing conclusions.

XI. CONCLUSIONS AND RECOMMENDATIONS: The conclusion of this small group of evaluators from the Fort Lewis Area Office is that the ESROC Expert System for built-up roofing is of value to the less experienced construction representative but requires some work to make it more convenient and less frustrating to use. The use of this program as a learning tool should be considered and a glossary of roofing terminology included. In construction, as in many other fields, there are often times when one item is unclear and a resource book is referred to in order to get clarification or additional

information. The computer is the ideal tool for leading people to the information that is being sought and it is recommended that this program be more flexible in that regard.

COMMENTS ON ESROC EXPERT SYSTEM ROUGH DRAFT DATED JULY 1988 - OCTOBER 1989

FLASHING:

What is for flash_type: The statement "fastenings hold the flashing together" is probably not necessary. Con Reps know this.

Flashloc question seems confusing at first. Suggest asking if base flashing is at least 8 inches above the deck.

THE PROGRAM:

There is a lot of redundancy in the answer selections below each question. Rep will not like to read any more than they need to. For example, when you ask what type of deck, the first selection is "steel = the deck type is steel." This could be improved by just listing the words steel, concrete, and gypsum. Another redundancy is where you have several choices and words are repeated, for example:

What type of material is the membrane being placed on? (undrmemb)
1) = the membrane is going directly on the deck
2) = the membrane is going on an asphalt felt vapor retarder
3) = the membrane is going on a base sheet
4) = the membrane is going on a laminated sheet
5) = the membrane is going on a layer of insulation

could read:

What type of material is the membrane being placed on?
1) directly on the deck
2) an asphalt felt vapor retarder
3) a base sheet
4) a laminated sheet
5) a layer of insulation

When you go through a hundred questions, reducing the reading time will also reduce any frustration the rep might have in reading the questions. Also, I don't see the value of inserting the code name for the question after the question. This just takes up space and visually clutters up the screen.

It would be useful to be able to back up in the program by hitting the Esc key like in Lotus 123 and other programs.

From a user point of view, hitting a function key like F1 instead of typing in "whatis", would be easier (note that "wha" works but one key would be quicker).

Another suggestion to make this program more friendly is to write the program so that hitting the selection (1,2,3...) incorporates the return key and makes the selection.

The following questions should be yes/no questions:

1. Are the nailers treated with waterborne salt preservative?
2. Is the flash point and EVT on the bills of lading or container?
3. Were the repetitive deficiencies for BUR discussed?
4. Is insulation being placed on the deck?
5. Is the steel deck the vapor retarder?
6. Are nailers required by the contract drawings?
7. Are nailers continuous along the perimeter?

On second thought, maybe it would be better to stick with the 1,2,3... format throughout. This way, its faster (no words to type in) when you are running through the program quickly to see what conclusions are reached on a certain question or subject, given a certain response to the questions. It might also be good to have a default value already printed at the cursor so all you would have to do is to hit return to keep going. Sometimes there is an obvious answer if the Rep has done any roofing whatsoever in their lives.

To save Reps added typing, state that you can use the first letter of the selection instead of saying that you have to enter "explain" or "

MATERIAL:

The question on whether the steel deck is the vapor barrier should be a yes/no question.

GENERAL:

I recommend a menu selection called glossary which then went to a listing a roofing terms for selection of the definitions. This should include words in the program and other roofing terms. See NRCA Roofing and Waterproofing Manual.

Suggest being consistent in calling the meeting prior to roofing, the "Preparatory Meeting." Delete references to the roof preparation conference and the preroofing conference.

Suggest taking the words "runny" and "runniness" out and replacing them with viscosity or flow. Most Reps know what viscosity means - especially if they change their own oil!

The Why choice doesn't seem helpful at all - suggest deleting to avoid confusion. It doesn't help to know why the computer needs to know some info. Most Reps won't care, they want info that they can use. Some of the Why info is useful though, for example, when you ask the question "What type of material is the membrane being placed on? (undrmemb)", the Why states that this is important if the membrane is going directly on the steel deck because then attention needs to be focused on sealing all the joints in the steel deck.

It would be useful to discuss application of BUR over an existing BUR roof.

It seems like some questions are written in a way as to hold back the information until whatis is entered. For example: Are the cant strips installed as required? If the User is unsure of the "required" installation method, then of course, he/she will type in whatis. When that is done, then you learn that "using hot bitumen" is the required method. Why not make the question "Are the cant strips installed using hot bitumen?"

The other item in this whatis explanation is sort of a definition of cant strip. This definition should be more precise if its going to be in there (I think it should be in a separate glossary function available at any time in the program) Here's the NRCA definition: a bevelled shaped strip of wood or wood fiber that fits into the angle formed by the intersection of a horizontal surface and a vertical surface. The 45 degree slope of the exposed surface of the cant strip provides a gradual angular transition from the horizontal surface to the vertical surface. ROOFPREP:

The question about having the required people at the preparatory meeting at first seems unclear but is explained in whatis. Suggest using the words "key

contractor and sub personnel" instead of "required people." Also, there usually isn't a carpentry subcontractor. The general contractor or the roofing contractor usually installs the wood with their own carpenters. For built-up roofing, the material manufacturers rep hardly ever attends the preparatory meeting and the specs don't require this.

The question "Is the roof deck ready for construction?" seems a bit ambiguous at first. Suggest rewording this question, maybe something like "Is the roof deck complete and suitable for roofing operations to begin?"

PICTURES:

EDGE WOOD NAILERS AT EAVES, RAKES, AND AS INDICATED ON CONTRACT DRAWINGS - This drawing has something written at the bottom of the screen that can't be read.

BITUMEN STOPS EAVES AND RAKES - Correct mispelled word "during." Also, this drawing has something written at the bottom of the screen that can't be read.

INSUL:

The question "Are continuous nailers along the perimeter?" should read "Are nailers continuous along the perimeter?"

The question "Is the roof ready for insulation?" should read "Is the deck ready for insulation?"

Suggest rewording the question "Is long edge of ins. oriented to slope/flutes?" to "Is long edge of ins. parallel to the roof slope?"

Further explanation is required for the question "Are insulation joints taped?." The whatis doesn't explain why you would want to tape the joints. I wouldn't think that you would want to align the joints that are perpendicular to the roof slope as well as the ones parallel to the roof slope just because the joints are taped. I thought that joints were taped to help keep the bitumen or moisture from going though. The whatis needs to say "perpendicular to the roof slope" instead of just perpendicular joints.

MEMBRANE:

Why do the cants have to be wood, fiberboard, or perlite (other than because if they aren't, they are the wrong material).

Suggest listing the typical size fire extinguisher required to be with the bitumen kettle in the Whatis for (fire). See EM 385-1-1 for info.

The Whatis for the question on felts layed perp. to the slope could be alittle more informative by stating that this is "shingle fashion" to help reduce damage from flowing water.

THE COMPUTER:

The compaq is a very nice laptop computer, however, I don't see many Reps taking it to the roof with them because of bulk, they may drop it and have to pay for it, and the screen might be hard to see during good roofing weather. It is excellent for taking in the car though, and thats probably close enough to the roof.

I didn't like the way the computer beeps for about one second and the locks up if you don't hit any buttons for a couple minutes. After the beep, it would be nice to have about 10 seconds or so to hit a key and keep it going. This is especially true since you can't jump around in the program and would have to answer all the questions over again.

ANNEX 3

14 SEPTEMBER 1989
GOSSELIN

FOR YOUR INFORMATION
SUBJECT: CERL ROOFING COMPUTER PROGRAM (ESROC)

This report is in response to a Septembr 12th and 13th site visit to the Corps Yakima Field Office inspecting built-up roofing on Contract No. YFC-89-B-0034; Re-roof Various Buildings. The main purpose of this visit was to evaluate the recently developed CERL-ESROC computer built-up roofing program (rough draft, June 1987). The program is aimed at assisting quality assurance (QA) field personnel inspecting built-up roofs.

The program started with a menu of the three main inspection parameters; preparation, initial, and follow-up. Each of these inspection phases had subparameters to evaluate the construction process. I went through the computer program utilizing the commands; whatis, why, graphics, and recommendations used to explain the construction of built-up roofing. The following are my comments on the use of this computer program.

The graphics were extremely helpful (a picture is worth a thousand words) and could be more intensively used. The "whatis" picture for bitumen strips for eaves and rakes under Membrane was poor and should be redone.

Sometimes the text did not fit on the screen. I am not sure if this is a software or hardware problem.

Spelling throughout the program needs to be cleaned-up. An example of the misspelling is; porper for proper and aluminumb for aluminum. Also under Membrane the squeegeeing text should read "not pushed" instead of "not pulled".

The "why" command usually did not answer a question but reiterated the question therefore this was not helpful. A typical example would be the question "are continuous nailers along the perimeter?" and the "why" response was "because if perimeter nailers are not continuous this would suggest that nailers must be continuous around the perimeter". The "whatis" was very informative along with the "graphix" explanation.

This contract is for built-up roofs on wood decks, several of the subparameters did not have a wood option.

The program would be more efficient and useful if you could jump around more easily instead of going through step by step.

Although I went out having minimal knowledge on built-up roofing construction through the use of the computer program and the assistance of Mr. Victor Sandvig, Corps Construction Representative I have gained a solid understanding of the parameters in roofing inspection.

I feel the computer program is an excellent tool to be used by field personnel both experienced and unexperienced in built-up roofing inspection. In my opinion the program should be available for all QA on built-up roofing jobs. I hope to see this same method applied to paving jobs, insulation, electrical, foundations, etc.

If there are any question regarding this report contact Jolene Gosselin at the Ft. Lewis Area Office (206)967-6937.

JOLENE GOSSELIN
CIVIL ENGINEER

cc:
Berg
Sandvig
file

APPENDIX B: Changes Made and Planned Future Changes to ESROC

I. Completed Corrections

A. All of the files have been spell checked.

B. All answers to questions were given a word response instead of a number (yes/no instead of 1/2). This was done in response to the requirements of the Interactive Voice/Expert System.

C. Corrections to the FLASHING module:

1. The recommendation "Flash_Type" has been modified so as not to contain unnecessary information.
2. The question "Flashloc" has been reworded.

D. The meeting prior to roofing is now consistently called the "preparatory meeting."

E. All instances of the word "runny" have been replaced by the word "viscous."

F. The cant strip question and whatis have been cleaned up.

G. Corrections to the ROOFPREP module:

1. The list of people to attend the preparatory meeting has been corrected, both in terminology and in content.

2. The question "Is the roof ready for construction?" has been improved; however, there was not enough room to include the suggested change.

H. Corrections to the INSUL module:

1. The three problem questions have been modified.

2. The information about the taping of joints has been corrected.

I. Corrections to the MEMBRANE module:

1. The module now states that the fire extinguisher by the bitumen kettle should not be less than 2-A.

2. The whatis about laying felts perpendicular to the slope now includes "shingle fashion."

II. Planned Future Changes to ESROC

A. The changes to the Critic program suggested by the field test sites are valuable suggestions, however they will require time to implement. Examples of these changes are using the Esc key to back up in the program, using function keys, changing the path used to read a recommendation, and making any changes to "why."

B. A glossary of roofing terms is being considered. (On a prototype expert system for roof maintenance there is a glossary with pictures of the defects.)

C. ESROC currently discusses application of BUR as a new roof, but will later be expanded to include application over an existing BUR roof.

D. For the MEMBRANE module, the optimal way of inquiring about the material of the cants is still being considered.

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